



Internal Hernia After Laparoscopic Roux-en-Y Gastric Bypass: a Correlation Between Radiological and Operative Findings

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Abstract

Background Even though internal hernia (IH) after a laparoscopic Roux-en-Y gastric bypass (LRYGB) is a well-known entity for bariatric surgeons and radiologists, accurate diagnosis remains difficult. The aim of this study was to evaluate the sensitivity and specificity of ten different CT findings in patients with a proven internal hernia after a LRYGB.

Methods A retrospective analysis of all LRYGB patients who underwent an explorative laparoscopy for abdominal pain has been performed. Preoperative CT scans were individually reviewed by two radiologists specialized in abdominal CT imaging in a randomized blind way. These results were compared with the operative reports.

Results Between 2004 and 2013, 7,328 patients underwent a LRYGB. One hundred sixty nine of these patients underwent an explorative laparoscopy for abdominal pain after a LRYGB, 131 of which had a preoperative CT scan. Of these 131 patients, 72 suffered from an IH. Fifty-nine patients had no IH and served as control group. Mesenteric swirl was the best predictor with for reader 1 a sensitivity of 68 % and specificity of 86 % and for reader 2 a sensitivity of 89 % and specificity of 63 %. Other signs had an even larger interobserver variability.

Conclusions A CT scan can help in confirming the diagnosis of an IH, especially if a mesenteric swirl is present. However, since the presented sensitivities are variable and do not reach 100 %, IH might be missed, implicating that a high index of

suspicion with a low threshold for explorative laparoscopy/-tomy remains the cornerstone of appropriate treatment.

Keywords Gastric bypass · Internal hernia · Complication · Obstruction · Radiology · Peterson

Introduction

Laparoscopic Roux-en-Y gastric bypass (LRYGB) is considered the gold standard surgical treatment for morbid obesity and has become the most common bariatric procedure [1]. Besides an important and persistent weight loss, it can improve or resolve obesity-related comorbidities (hypertension, diabetes, hypercholesterolemia and obstructive sleep apnoea) [2]. But, the altered anatomy can induce some surgery-specific complications (marginal ulcer, internal hernia, stenosis, gastro gastric fistula), and where, as in a non-bariatric population, abdominal pain without peritoneal signs is mainly a non-surgical problem, in a bariatric population, important surgical complications might be missed. One of these potential devastating complications is an internal herniation of the small bowel, which can result in bowel ischemia or even death [3, 4]. Most patients suffering from an internal hernia have intermittent and chronic intestinal obstructive complaints (post prandial nausea, anorexia, bloating, cramps) [5]. It may also present as an acute event with severe colicky pains in the left hypochonder irradiating to the back, nausea, limited vomiting, bloating and in a later phase, peritoneal tenderness. Laboratory results and abdominal X-rays are often aspecific or negative and only become positive when ischemia sets in. So, early diagnosis is of the utmost importance, and vigilance is required when confronted with a bariatric patient complaining of abdominal pain. Upper GI series can be helpful, but a CT scan remains the imaging modality of choice [6, 7].

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However, even for the experienced radiologist, diagnosing an internal hernia might prove to be difficult. Radiological signs on CT scan have been reported in small series, but the reliability is often disappointing [8, 9]. The aim of this study was to evaluate the sensitivity and specificity of CT findings in patients with a proven internal hernia after an antecolic, antegastric LRYGB.

Materials and Methods

With approval from an independent ethics commission at our institution, we retrospectively analysed our prospectively collected database of 7,328 patients who received a laparoscopic gastric bypass between March 2004 and February 2013. The bypass procedure was performed as described by Dillemans et al. [10] and implies a laparoscopic, fully stapled, standardized, antecolic, antegastric Roux-en-Y gastric bypass with a Roux limb of 130 cm in patients with a BMI less than 50 kg/m² and 200 cm in patients with a BMI more than 50 kg/m². The mesentery was not divided, but the greater omentum was systematically split at the left side [10]. Mesogaps were not closed until mid-2013. We identified 169 patients needing a surgical exploration for obstructive complaints. Of these 169 patients, 107 patients had a CT scan at our institution and 29 were referred with a CT scan.

Thirty-three patients with mild but recurrent symptoms of an internal hernia underwent a laparoscopic exploration solely based on clinical suspicion (without prior CT scan) and were excluded from this study. In the clinical setup of these patients, other causes of upper GI pathology as marginal ulcers and gallstones have been

ruled out. Serological findings were aspecific and did not contribute to the decision-making process to perform an explorative laparoscopy (Fig. 1).

The preoperative CT scans at our institution were performed with a multirow CT scan with at least 16 slides. Oral contrast was given to all patients without severe nausea or vomiting. One hundred cubic centimetres of intravenous contrast (Xenetix® 350 mg/ml) was given to patients with normal renal clearance. Subsequently the patients were scanned with a delay of 85 s.

For the CT scans performed at other institutions, both radiologists agreed that the quality of most scans were sufficient for correct interpretation after reviewing the scanning specifications. One referred patient was excluded due to insufficient quality of the CT scan. Four CT scans of our institution were excluded due to technical problems with the recall of the images.

Evaluation of Images

All CT examinations were reviewed retrospectively on an individual base in a randomized blind way. The readers were 2 radiologists specialized in abdominal CT imaging with 14 and 16 years of experience. Prior to the study, the readers were given a short lecture about the specific surgical procedure and took the time to read articles covering the topic [8, 9, 11].

Eight previously described signs and two additional signs were used to evaluate the CT scans [8, 9]. CT signs included were swirl sign, mushroom sign, hurricane eye, small-bowel obstruction, clustered loops in the left hypochonder, small bowel behind the superior mesenteric artery (SMA), right-sided location of the jejunojunal anastomosis, enlarged lymph nodes, pathological

Fig. 1 Flow chart illustrating the diagnostic decisions and operative findings

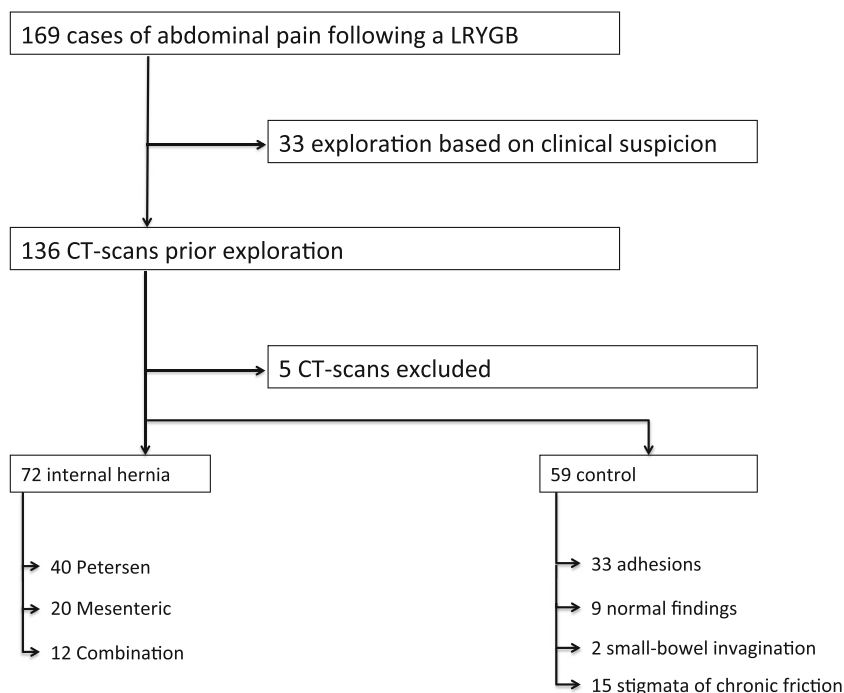


Fig. 2 Left: swirl sign around the SMA (*arrow*); right: mushroom sign: protrusion of small bowel between SMA and mesenteric arterial branch (*arrows*)



amount of abdominal fluid and dilated remnant stomach (Figs. 2, 3, 4 and 5).

Pathological abdominal fluid was defined as a quantity of free abdominal fluid considered to be abnormal for the reader; a dilated remnant stomach was defined as a fluid-filled stomach with or without an air bubble.

The two readers were given a checklist with the 10 signs combined with a scale which depicted the degree of confidence of an internal hernia (IH) being present as follows: 0, no IH; 1, probably no IH; 2, probably an IH; and 3, definitely an IH. If an internal hernia was suspected, the type of herniation had to be specified (Petersen, mesojejunal or both).

Statistical Methods

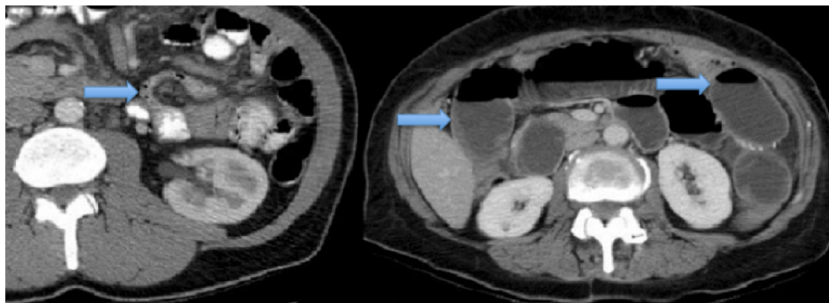
Statistical analyses were performed using IBM® SPSS® version 21. The demographics of the two groups were compared with a Fisher's exact test for discrete variables and a Student's *t* test for continuous variables. The sensitivity and specificity of the different CT signs were calculated using contingency tables. Subanalyses on patients with a Petersen or mesojejunal hernia were performed. Statistical significance was set at an alpha of 0.05 for all analyses.

Results

Demographics

One hundred thirty one patients (31 males, 100 females) with abdominal pain following a LRYGB were included. An internal hernia at the explorative laparoscopy was identified in 72

Fig. 3 Left: hurricane eye: tubular mesentery with small bowel around (*arrow*); right: dilated small-bowel loops (*arrows*)



cases (40 at the Petersen, 20 at the mesojejunal defect, 12 at a combination of both); 59 patients had no internal hernia at exploration and served as control group. In this control group, 33 patients had (sub) obstructive adhesions, 9 normal findings, 2 patients had a small-bowel invagination and 15 patients had stigmata of chronic friction at one of the mesenteric defects with thickening of the peritoneum without active herniation. No statistical difference in patient demographics was seen between the two cohorts (Table 1).

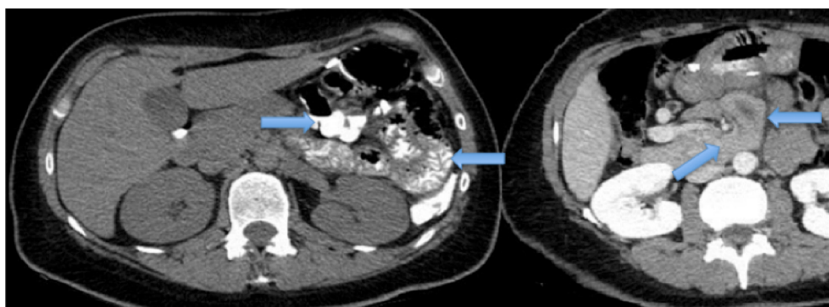
The surgical exploration was performed at an average of 857 days (range 180–2,573 days) after the LRYGB. No peri-operative death was encountered. Eight patients needed a conversion to laparotomy because of incarceration of the bowel at the hernia site ($n=7$: 2 Petersen, 2 mesojejunal, 3 combination) or due to extensive adhesions ($n=1$).

CT Scan Evaluation

The sensitivity and specificity for all 10 CT signs of an internal hernia are shown in Table 2. The mesenteric swirl was the best predictor of an internal hernia with for reader 1 a sensitivity of 68 % and specificity of 86 % and for reader 2 a sensitivity of 89 % and specificity of 63 %. A small-bowel loop behind the SMA had respective sensitivities and specificities of 61–43 and 86–95 %. Other signs had an even larger interobserver variability and lower overall sensitivities or specificities. Reader 2 had a significantly higher sensitivity than reader 1 for protrusion of a small-bowel limb between the SMA and a mesenteric arterial branch (mushroom sign) and tubular mesenteric fat surrounded by small-bowel loops (hurricane eye, Table 2).

No difference in sensitivity or specificity of independent CT signs could be observed in subgroup analysis of patients with a

Fig. 4 Left: clustered small-bowel loops in left hypochondrium (*arrows*); right: small bowel behind the SMA (*arrows*)



Petersen or mesojejunal hernia alone. Seemingly, there is no specific CT pattern that can differentiate between the two types of internal hernias.

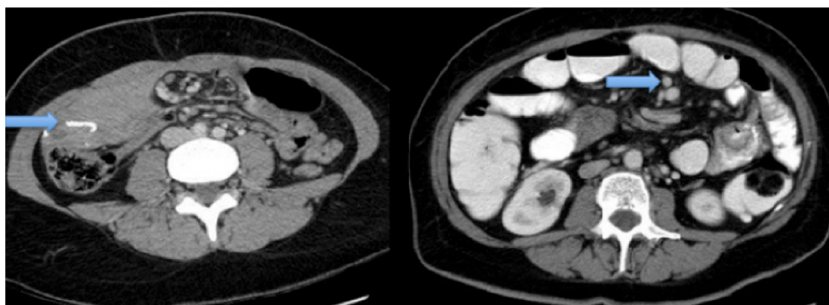
Surgical Evaluation and Treatment

The patient is placed in a standard beach chair position. After insufflation with a verres needle, a 10-mm scopetrocar is introduced and three 5-mm trocars are placed under direct vision: one in the left flank, one in the right flank and one under the xyphoid. The gastroenterostomy is evaluated for obstructive adhesions and the Peterson space (under the alimentary limb) is identified to exclude an internal hernia. After this, the surgeon stands on the left side of the patient to run off the small bowel from the caecum to the entero-enterostomy to identify a possible internal hernia at this site. If an internal hernia is present, the small bowel is deherniated. In every case, both mesogaps are closed if they are not obliterated by adhesions. The Peterson space, where the surgeon stands between the legs, is closed with a non-resorbable V-Loc 2-0; the mesojejunal gap (where the surgeon stands on the left side of the patient), with an ethybond 2-0.

Discussion

Abdominal pain after bariatric surgery remains an enigma for many, and with the increasing frequency of bariatric procedures, this diagnostic challenge is likely to increase. Besides a good history and clinical examination, a CT scan with oral and intravenous contrast is often requested for further diagnosis.

Fig. 5 Left: right-sided entero-entero anastomosis (*arrow*); right: enlarged lymph nodes (*arrow*)



However, the interpretation of a CT scan after LRYGB can prove to be a challenge on its own.

Before ordering the scan, the question rises whether CT is the best modality to confirm the clinically suspected diagnosis. For a variety of causes, other investigations are considered as the first line investigation (e.g. gastroscopy for marginal ulcer, oral glucose tolerance test for dumping, echography for gallbladder disease). For internal herniation, CT is believed to be the diagnostic procedure of choice with sensitivities and specificities of up to 100 and 90 %, respectively, reported in literature if a mesenteric swirl is present [8].

When CT has been decided upon to exclude an internal hernia, one must bare in mind the patient characteristics and altered anatomy and how the procedure has been performed. Several procedural differences have proven to influence the occurrence of an internal hernia. Quebbemann et al. showed in 400 patients that a right-oriented LRYGB significantly reduces the risk of internal hernia behind the Roux limb mesentery (Petersen's space) [12]. Brolin et al. reported a significant reduction (2.6 to 0.5 %) in internal hernia frequency after antecolic LRYGB if mesenteric defects were closed [13]. De la Cruz-Munoz et al. reported on 2,079 patients with an LRYGB a reduction of IH frequency from 11.7 to 0.1 % by closing the jejunojejunal anastomotic mesenteric defect with a running, permanent suture [14]. There are also theoretical and patient-specific factors to consider. Gutt et al. demonstrated that an open procedure gives more adhesions, theoretically making an internal hernia less likely [15]. Ahmed et al. stated that internal hernias mainly occur after a significant weight loss (EBWL >50 %) and confirmed that an antecolic approach reduces the incidence of internal hernia (2.4 vs 0.6 %) [16]. Ortega et al. reported a low incidence (0.3 %) of internal hernias

Table 1 Patient demographic characteristics

	No hernia (±SD)	Internal hernia (±SD)	<i>p</i> value
Sex (male/female)	10/49	22/50	0.101
Age at LRYGB (years)	41.3±11.0	38.3±10.5	0.108
Initial BMI (kg/m ²)	41.0±5.6	39.3±5.1	0.072
BMI at exploration (kg/m ²)	25.9±4.4	25.0±3.7	0.221
Excess weight loss (%)	79.3±20.8	82.4±24.9	0.439
Time to event (days)	834±585	576±599	0.684

LRYGB laparoscopic Roux-en-Y gastric bypass, BMI body mass index

by performing a right-oriented antecolic, antegastric LRYGB without splitting the greater omentum or mesenterium [17].

All this data helps in identifying anatomical structures and lining up the differential diagnosis, but it takes more to diagnose an internal hernia and its specific site correctly on CT scan. Depending on the type of surgery performed, four types of IH can occur [11]. Transmesocolic, Petersen, mesojejunal and jejunojejunal hernias have been described. We performed an antecolic gastro-jejunostomy and a fully stapled jejunojejunostomy making a transmesocolic and jejunojejunal hernia impossible [10]. Several studies have described the CT findings in case of IH with their respective sensitivities and specificities in small series.

Marchini et al. reviewed the scans obtained less than 48 h before surgery of 34 acutely symptomatic IH patients [11]. They reported on hernia type-specific CT signs. For a Petersen's hernia with small-bowel obstruction, they found two signs significantly associated with that type of hernia. A sac-like cluster of small-bowel loops displaced towards the

Table 2 Sensitivity and specificity of CT signs of an internal hernia following LRYGB

	Reader 1		Reader 2	
	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)
Swirl sign	68	86	89	63
Mushroom signs	22	97	67	76
Hurricane eye	7	100	93	54
Small-bowel obstruction	44	71	18	76
Clustered loops	18	98	36	27
Small bowel behind superior mesenteric artery	61	86	43	95
Right-sided anastomosis	6	98	11	100
Enlarged lymph nodes	36	88	18	95
Ascites	56	56	65	59
Dilated remnant stomach/bilio-pancreatic limb	10	92	24	83

left mid-abdominal wall, coming from behind the Roux limb and in front of the angle of Treitz and a horizontal course of (engorged) superior mesenteric vessels towards the left abdominal wall. For a mesojejunal hernia, they found in their population that a cluster of dilated bowel segments adjacent to the jejunojejunal anastomosis and pressed against the anterior abdominal wall without overlying omental fat combined with crowding and engorgement of the mesenteric blood vessels was typical. Lockhart et al. reviewed the CT scans of 18 patients with surgically proven internal hernia and compared them with 18 negative controls [9]. They found that, of the seven CT signs that were checked, mesenteric swirl was the single best predictor of internal herniation, with sensitivities for the three radiologists of 61-78-83 % and specificities of 94-89-67 %. They did not correlate individual signs with specific types of hernias. Iannuccilli et al. reported on the sensitivity and specificity of eight CT signs in nine case-matched patients with surgically proven internal hernia [8]. CT scans were reviewed by three radiologists, and they found that a mesenteric swirl sign was the most sensitive (78-80-100 %) and specific (80-89-90 %). This sign also demonstrated the highest interobserver agreement. Other CT signs such as mushroom sign, hurricane eye sign and small bowel behind SMA were relatively insensitive, and interobserver agreement was only moderate at best.

These results were confirmed in our study where the mesenteric swirl had respective sensitivities and specificities of 68-89 % and 86-63 %. The sensitivity and specificity of the mushroom sign, the hurricane eye or the small bowel behind the superior mesenteric artery had an even large interobserver variability or lacked sensitivity. The other investigated signs did not provide additional information to diagnose an internal hernia and are therefore of no importance when one tries to identify an IH on CT scan. When performing subgroup analysis regarding the type of IH, no difference in sensitivity or specificity of independent CT signs could be observed, implicating that the difference between a Petersen's hernia and mesojejunal hernia could not be made based on the CT signs we investigated.

From a surgical perspective, CT sensitivity is more important than specificity. The clinical consequences of missing an IH are far more serious than performing an unnecessary explorative laparoscopy. If sensitivity is not reaching 100 %, the decision to go for surgery will still be more dependent on clinical examination than on radiological evaluation.

Conclusion

CT scan can help confirm the diagnosis of internal hernia after gastric bypass, especially if a mesenteric swirl is present. However, a high index of clinical suspicion with a low threshold for explorative laparoscopy/-tomy remains the cornerstone

of appropriate treatment. CT-graphic differentiation between a Petersen's and mesojejunal hernia was not possible in our analysis.

Conflict of Interest None of the authors (F. Goudsmedt, B. Deylgat, Kenneth Coenegrachts, Kris Van De Moortele, Bruno Dillemans) have conflicts of interest.

Statement of Informed Consent Informed consent was obtained from all individual participants included in the study. No identifying information was used in this study.

Statement of Human and Animal Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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